a height mapping system located at said measurement station comprising at least one sensor constructed and arranged both to measure positions of a plurality of points on a surface of said substrate in a first direction substantially perpendicular to said surface and to measure a position of said physical reference surface in said first direction, said lithographic apparatus constructed and arranged to create a height map, relative to said physical reference surface, from said positions of the plurality of points on the surface of the substrate;

a position measuring system located at said exposure station constructed and arranged to measure a position of said physical reference surface in said first direction, after movement of said second object table to said exposure station; and

a position controller constructed and arranged to control a position of said second object table in at least said first direction, during exposure of said target portion, in accordance with said height map and said position measured by said position measuring system.

2. (Twice Amended) Apparatus according to claim 1, wherein said controller is further arranged to control a tilt of said second object table about at least one axis perpendicular to said first direction in accordance with said height map.

3. (Twice Amended) Apparatus according to claim 1, wherein said sensor comprises a level sensor constructed and arranged to simultaneously measure positions in said first direction of a linear array of points.

4. (Twice Amended) Apparatus according to claim 1, wherein said sensor comprises a level sensor constructed and arranged to measure a position of a measurement beam reflected by at least one of said surface and said physical reference surface whose position in said first direction is to be measured.

5. (Twice Amended) Apparatus according to claim 4, wherein said level sensor comprises:

a projection grating;

projection optics constructed and arranged to project an image of said projection grating onto said at least one of said surface and said physical reference surface whose position in said first direction is to be measured;

a detection grating;

detection optics constructed and arranged to focus light reflected by said at least one of said surface and said physical reference surface to form on said detection grating an image of said projection grating; and

a detector constructed and arranged to detect Moiré patterns formed by an overlay of said image of said projection grating on said detection grating.

6. (Twice Amended) Apparatus according to claim 5, wherein said level sensor further comprises a radiation source or illuminator constructed and arranged to illuminate said projection grating with polychromatic radiation and wherein said projection optics and said detection optics comprise reflective optical elements.

C2 Cont'd

7. (Twice Amended) Apparatus according to claim 1, wherein said height mapping system comprises a first sensor constructed and arranged to detect at least one of the positions of said plurality of points on the surface of said substrate and the position of said physical reference surface and a second sensor constructed and arranged to detect a position in said first direction of said second object table substantially simultaneously with measurements by said first sensor.

8. (Twice Amended) Apparatus according to claim 7, wherein said second sensor comprises an interferometer.

C3 Cont

10. (Twice Amended) Apparatus according to claim 1, wherein said position measuring system is constructed and arranged to measure the position of said physical reference surface relative to the focal plane of said projection system.

11. (Twice Amended) Apparatus according to claim 1, wherein:

said second object table has a plurality of spaced-apart physical reference surfaces; and

said lithographic apparatus is constructed and arranged to create the height map relative to a reference plane defined by said plurality of physical reference surfaces.

12. (Twice Amended) Apparatus according to claim 1, further comprising:

a height mapping system located at said exposure station constructed and arranged to measure positions of a plurality of points on a surface of a substrate in a direction substantially perpendicular to said surface, said lithographic apparatus constructed and arranged to create a height map, relative to said physical reference surface, from said positions of the plurality of points on the surface of the substrate; and

a height calibrator constructed and arranged to compare height maps of said substrate prepared by each of said height mapping systems to derive a relative calibration for separate position detection systems provided at said measurement and exposure stations.

Please add claims 27–75 as follow:

27. (New) Apparatus according to claim 7, wherein said first sensor is said sensor and comprises a level sensor.

28. (New) Apparatus according to claim 7, wherein the measurement by said second sensor is made at a substantially same position in a plane substantially perpendicular to said first direction as the measurement by said first sensor.

29. (New) Apparatus according to claim 12, wherein:

said height mapping system located at said measurement station comprises a confidence sensor constructed and arranged to measure the positions in a direction substantially perpendicular to the substrate of the same plurality of points on the surface of the substrate as measured by the height mapping system located at said exposure station; and

said lithographic apparatus is constructed and arranged to create the height map used for comparison by the height calibrator, said height map created, relative to said physical reference surface, from said positions of the plurality of points on the surface of the substrate measured by the confidence sensor.

30. (New) Apparatus according to claim 1, wherein said lithographic apparatus is constructed and arranged to calculate from said height map Z, R_x, and R_y position setpoints for said position controller, wherein Z is in said first direction and X and Y are substantially perpendicular to said first direction.

31. (New) Apparatus according to claim 30, wherein said setpoints are calculated using one of a least squares method and a moving focus method.

32. (New) Apparatus according to claim 1, wherein said lithographic apparatus is constructed and arranged to calculate from said height map a sequence of Z, R_x, and R_y position setpoints for said position controller matched to an X-Y scan path of said second object table, wherein Z is in said first direction and X and Y are substantially perpendicular to said first direction.

33. (New) A lithographic projection apparatus comprising:

a first object table constructed and arranged to hold a mask;

a second, movable object table constructed and arranged to hold a substrate and having a physical reference surface fixed thereon;

a projection system constructed and arranged to image an irradiated portion of the mask onto a target portion of the substrate;

a positioning system constructed and arranged to move said second object table between an exposure station, at which said projection system can image said mask portion onto said substrate, and a measurement station;

a height mapping system, located at said measurement station, constructed and arranged to measure positions of a plurality of points on a surface of said substrate in a first direction substantially perpendicular to said surface, to measure a position of said physical reference surface in said first direction and to measure a position of said second object table in said first direction substantially simultaneously with the measurement of at least one of the positions of the plurality of points on the surface of said substrate and the position of said physical reference surface, said lithographic apparatus constructed and arranged to create a height map, relative to said physical reference surface, from said positions of the plurality of points on the surface of the substrate;

a position measuring system located at said exposure station constructed and arranged to measure a position of said physical reference surface in said first direction, after movement of said second object table to said exposure station; and

a position controller constructed and arranged to control a position of said second object table in at least said first direction, during exposure of said target portion, in

accordance with said height map and said position measured by said position measuring system.

34. (New) Apparatus according to claim 33, wherein said height mapping system comprises at least one sensor constructed and arranged both to measure the positions of the plurality of points on the surface of said substrate and to measure the position of said physical reference surface.

35. (New) Apparatus according to claim 33, wherein said controller is further arranged to control a tilt of said second object table about at least one axis perpendicular to said first direction in accordance with said height map.

C4 Cont

36. (New) Apparatus according to claim 33, wherein said height mapping system comprises a level sensor constructed and arranged to measure a position of a measurement beam reflected by at least one of said surface and said physical reference surface whose position in said first direction is to be measured.

37. (New) Apparatus according to claim 36, wherein said level sensor comprises:

a projection grating;

projection optics constructed and arranged to project an image of said projection grating onto said at least one of said surface and said physical reference surface whose position in said first direction is to be measured;

a detection grating;

detection optics constructed and arranged to focus light reflected by said at least one of said surface and said physical reference surface to form on said detection grating an image of said projection grating; and

a detector constructed and arranged to detect Moiré patterns formed by an overlay of said image of said projection grating on said detection grating.

38. (New) Apparatus according to claim 33, wherein said height mapping system comprises a first sensor constructed and arranged to detect at least one of the positions of said plurality of points on the surface of said substrate and the position of said physical reference surface and a second sensor constructed and arranged to detect a position in said first

direction of said second object table substantially simultaneously with measurements by said first sensor.

39. (New) Apparatus according to claim 38, wherein said first sensor is constructed and arranged both to measure the positions of the plurality of points on the surface of said substrate and to measure the position of said physical reference surface.

40. (New) Apparatus according to claim 38, wherein said second sensor comprises an interferometer.

41. (New) Apparatus according to claim 38, wherein the measurement by said second sensor is made at a substantially same position in a plane substantially perpendicular to said first direction as the measurement by said first sensor.

C4 Cont

42. (New) Apparatus according to claim 33, wherein said position measuring system comprises an image sensor mounted to said second object table and said physical reference surface comprises an upper surface of said image sensor.

43. (New) Apparatus according to claim 33, wherein said position measuring system is constructed and arranged to measure the position of said physical reference surface relative to the focal plane of said projection system.

44. (New) Apparatus according to claim 33, wherein:

said second object table has a plurality of spaced-apart physical reference surfaces; and

said lithographic apparatus is constructed and arranged to create the height map relative to a reference plane defined by said plurality of physical reference surfaces.

45. (New) Apparatus according to claim 33, wherein measurements of the position of said second object table and of at least one of the positions of the plurality of points on the surface of said substrate and the position of said physical reference surface are made at a substantially same position in a plane substantially perpendicular to said first direction.

46. (New) Apparatus according to claim 33, wherein said lithographic apparatus is constructed and arranged to calculate from said height map Z, R_x, and R_y position setpoints for said position controller, wherein Z is in said first direction and X and Y are substantially perpendicular to said first direction.

47. (New) Apparatus according to claim 46, wherein said setpoints are calculated using one of a least squares method and a moving focus method.

48. (New) Apparatus according to claim 33, wherein said lithographic apparatus is constructed and arranged to calculate from said height map a sequence of Z, R_x, and R_y position setpoints for said position controller matched to an X-Y scan path of said second object table, wherein Z is in said first direction and X and Y are substantially perpendicular to said first direction.

49. (New) A lithographic projection apparatus comprising:

a first object table constructed and arranged to hold a mask;

a second, movable object table constructed and arranged to hold a substrate and having a physical reference surface fixed thereon;

a projection system constructed and arranged to image an irradiated portion of the mask onto a target portion of the substrate;

a positioning system constructed and arranged to move said second object table between an exposure station, at which said projection system can image said mask portion onto said substrate, and a measurement station;

a height mapping system located at said measurement station and constructed and arranged to measure positions of a plurality of points on a surface of said substrate in a first direction substantially perpendicular to said surface and to measure at a substantially same position in a plane substantially perpendicular to said first direction positions of said second object table in said first direction, said lithographic apparatus constructed and arranged to create a height map, relative to said physical reference surface, from said positions of the plurality of points on the surface of the substrate and said positions of said second object table;

a position measuring system located at said exposure station constructed and arranged to measure a position of said physical reference surface in said first direction, after movement of said second object table to said exposure station; and

a position controller constructed and arranged to control a position of said second object table in at least said first direction, during exposure of said target portion, in accordance with said height map and said position measured by said position measuring system.

50. (New) Apparatus according to claim 49, wherein said height mapping system comprises at least one sensor constructed and arranged both to measure the positions of the plurality of points on the surface of said substrate and to measure a position of said physical reference surface in said first direction.

51. (New) Apparatus according to claim 49, wherein said controller is further arranged to control a tilt of said second object table about at least one axis perpendicular to said first direction in accordance with said height map.

52. (New) Apparatus according to claim 49, wherein said height mapping system comprises a level sensor constructed and arranged to measure a position of a measurement beam reflected by at least one of said surface and said physical reference surface whose position in said first direction is to be measured.

53. (New) Apparatus according to claim 52, wherein said level sensor comprises:

a projection grating;

projection optics constructed and arranged to project an image of said projection grating onto said at least one of said surface and said physical reference surface whose position in said first direction is to be measured;

a detection grating;

detection optics constructed and arranged to focus light reflected by said at least one of said surface and said physical reference surface to form on said detection grating an image of said projection grating; and

a detector constructed and arranged to detect Moiré patterns formed by an overlay of said image of said projection grating on said detection grating.

54. (New) Apparatus according to claim 49, wherein said height mapping system comprises a first sensor constructed and arranged to detect at least one of the positions of said plurality of points on the surface of said substrate and a position of said physical reference surface in said first direction and a second sensor constructed and arranged to detect the positions in said first direction of said second object table substantially simultaneously with measurements by said first sensor.

55. (New) Apparatus according to claim 54, wherein said first sensor is constructed and arranged both to measure the positions of the plurality of points on the surface of said substrate and to measure the position of said physical reference surface.

56. (New) Apparatus according to claim 54, wherein said second sensor comprises an interferometer.

57. (New) Apparatus according to claim 49, wherein said position measuring system comprises an image sensor mounted to said second object table and said physical reference surface comprises an upper surface of said image sensor.

58. (New) Apparatus according to claim 49, wherein said position measuring system is constructed and arranged to measure the position of said physical reference surface relative to the focal plane of said projection system.

59. (New) Apparatus according to claim 49, wherein:

said second object table has a plurality of spaced-apart physical reference surfaces; and

said lithographic apparatus is constructed and arranged to create the height map relative to a reference plane defined by said plurality of physical reference surfaces.

60. (New) Apparatus according to claim 49, wherein said lithographic apparatus is constructed and arranged to calculate from said height map Z, R_x, and R_y position setpoints for said position controller, wherein Z is in said first direction and X and Y are substantially perpendicular to said first direction.

61. (New) Apparatus according to claim 60, wherein said setpoints are calculated using one of a least squares method and a moving focus method.

62. (New) Apparatus according to claim 49, wherein said lithographic apparatus is constructed and arranged to calculate from said height map a sequence of Z, R_x, and R_y position setpoints for said position controller matched to an X-Y scan path of said second object table, wherein Z is in said first direction and X and Y are substantially perpendicular to said first direction.

63. (New) Apparatus according to claim 49, wherein said height mapping system is constructed and arranged to measure a position of said physical reference surface in said first direction and to measure at a substantially same position in a plane substantially perpendicular to said first direction a position of said second object table in said first direction.

64. (New) A lithographic projection apparatus comprising:

a first object table constructed and arranged to hold a mask;

a second, movable object table constructed and arranged to hold a substrate and having a physical reference surface fixed thereon;

a projection system constructed and arranged to image an irradiated portion of the mask onto a target portion of the substrate;

a positioning system constructed and arranged to move said second object table between an exposure station, at which said projection system can image said mask portion onto said substrate, and a measurement station;

a height mapping system located at said measurement station and constructed and arranged to measure positions of a plurality of points on a surface of said substrate in a first direction substantially perpendicular to said surface, to measure a position of said physical reference surface in said first direction and to measure at a substantially same position to the measurement of said physical reference surface in a plane substantially perpendicular to said first direction a position of said second object table in said first direction, said lithographic apparatus constructed and arranged to create a height map, relative to said physical reference surface, from said positions of the plurality of points on the surface of the substrate;

a position measuring system located at said exposure station constructed and arranged to measure a position of said physical reference surface in said first direction, after movement of said second object table to said exposure station; and

a position controller constructed and arranged to control a position of said second object table in at least said first direction, during exposure of said target portion, in accordance with said height map and said position measured by said position measuring system.

65. (New) Apparatus according to claim 64, wherein said height mapping system is constructed and arranged to measure at a substantially same position to the measurement of said plurality of points in a plane substantially perpendicular to said first direction positions of said second object table in said first direction, said lithographic apparatus constructed and arranged to create the height map, relative to said physical reference surface, from said positions of the plurality of points on the surface of the substrate and said positions of said second object table.

C4 Cont

66. (New) Apparatus according to claim 64, wherein said height mapping system comprises at least one sensor constructed and arranged both to measure the positions of the plurality of points on the surface of said substrate and to measure the position of said physical reference surface in said first direction.

67. (New) Apparatus according to claim 64, wherein said height mapping system comprises a first sensor constructed and arranged to detect at least one of the positions of said plurality of points on the surface of said substrate and a position of said physical reference surface in said first direction and a second sensor constructed and arranged to detect the positions in said first direction of said second object table substantially simultaneously with measurements by said first sensor.

68. (New) Apparatus according to claim 67, wherein said first sensor is constructed and arranged both to measure the positions of the plurality of points on the surface of said substrate and to measure the position of said physical reference surface.

69. (New) Apparatus according to claim 67, wherein said second sensor comprises an interferometer.

70. (New) Apparatus according to claim 64, wherein said position measuring system comprises an image sensor mounted to said second object table and said physical reference surface comprises an upper surface of said image sensor.

71. (New) Apparatus according to claim 64, wherein said position measuring system is constructed and arranged to measure the position of said physical reference surface relative to the focal plane of said projection system.

72. (New) Apparatus according to claim 64, wherein:

said second object table has a plurality of spaced-apart physical reference surfaces; and

said lithographic apparatus is constructed and arranged to create the height map relative to a reference plane defined by said plurality of physical reference surfaces.

73. (New) Apparatus according to claim 64, wherein said lithographic apparatus is constructed and arranged to calculate from said height map Z, R_x, and R_y position setpoints for said position controller, wherein Z is in said first direction and X and Y are substantially perpendicular to said first direction.

74. (New) Apparatus according to claim 73, wherein said setpoints are calculated using one of a least squares method and a moving focus method.

75. (New) Apparatus according to claim 64, wherein said lithographic apparatus is constructed and arranged to calculate from said height map a sequence of Z, R_x, and R_y position setpoints for said position controller matched to an X-Y scan path of said second object table, wherein Z is in said first direction and X and Y are substantially perpendicular to said first direction.

See the attached Appendix for the changes made to effect the above claims.